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Detection of Abnormal Tumor Regions in Ultrasonic Thyroid Images using SVM Classification Method

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***Abstract:** Detection of tumor or abnormal regions in thyroid gland is difficult task in human. The following methods are presently used for detecting the abnormal regions in thyroid gland as blood test, sample testing from thyroid gland and image processing method. This paper develops a methodology to detect the tumor regions in thyroid images using image registration and image enhancement technique. The Support Vector Machine (SVM) classifier is operated in two modes as training pattern generation and testing mode. The generation of training pattern from both normal and abnormal ultrasonic thyroid images. This proposed method for thyroid tumor region detection obtains 96.54% of sensitivity, 97.57% of specificity and 98.56% of average tumor segmentation accuracy.*

***Keywords:** Tumor, thyroid, images, SVM, mode.*

I. INTRODUCTION

Thyroid gland is essential for segregating the thyroid hormones which helps to regulate the various functional activities in human body [6]. This thyroid gland supports human organs development which is also responsible for various hormones balance activity functionalities [7]. Fig.1 shows the thyroid gland in human neck.

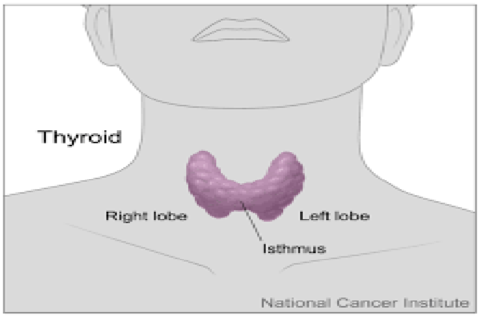

Fig. 1 Thyroid gland

Detection of tumor or abnormal regions in thyroid gland is difficult task in human. The following methods are presently used for detecting the abnormal regions in thyroid gland as blood test, sample testing from thyroid gland and image processing method. Among these present methods, image processing method is known as simple and efficient method for detecting and locating the tumor abnormal regions in thyroid gland [8].

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In this paper, ultrasonic imaging method is used for detecting the abnormal regions in thyroid images. The thyroid gland is completely scanned by the ultrasonic scanner and the scanned image is further processed using various image processing methods in computer processing methods. This paper uses soft computing methods as the classification algorithms for detecting the abnormal regions in scanned thyroid images.

Ma et al. (2017) proposed a thyroid tumor region segmentation methodology for locating the abnormal regions in ultrasonic thyroid images using cascaded Convolutional neural networks. The authors developed this proposed method on various feedback propagation models. Li et al. (2012) utilized extreme machine learning approach for detecting the tumor regions in ultrasonic thyroid images. This developed framework was analyzed on various thyroid image dataset with various background environments in order to validate the simulation results on the proposed method.

Dogantekin et al. (2011) used Support Vector Machine (SVM) classification method for detecting and locating the tumor regions in ultrasonic thyroid images. The authors performed various discriminate analysis methods for analyzing the located thyroid tumor regions for improving the segmentation accuracy. The authors obtained 91.86% of classification accuracy using their discriminate analysis methods on various thyroid image dataset. Chen et al. (2011) developed three stage expert detection and diagnosis system for locating the abnormal tumor regions in thyroid images. The developed methodology was analyzed on various expert systems in order to improve the tumor segmentation accuracy on various dataset. Ozyilmaz et al. (2002) detected thyroid tumor regions in thyroid images using neural network classification approach. This method detected and segmented the abnormal tumor regions from the ultrasound thyroid images using its training and testing configuration methods.

II. PROPOSED METHODOLOGY

This paper develops a methodology to detect the tumor regions in thyroid images using image registration and image enhancement technique. The entire process for tumor region detection in ultrasonic thyroid images is shown in Fig.2. The SVM classifier is operated in two modes as training pattern generation and testing mode. The generation of training pattern from both normal and abnormal ultrasonic thyroid images is shown in Fig.2 and its corresponding classification of thyroid images into normal and abnormal is illustrated in Fig.3.

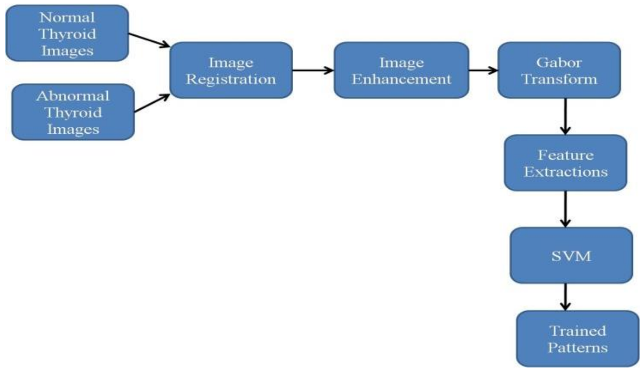

Fig. 2. Thyroid Tumor detection using image registration and SVM (Training pattern generation)

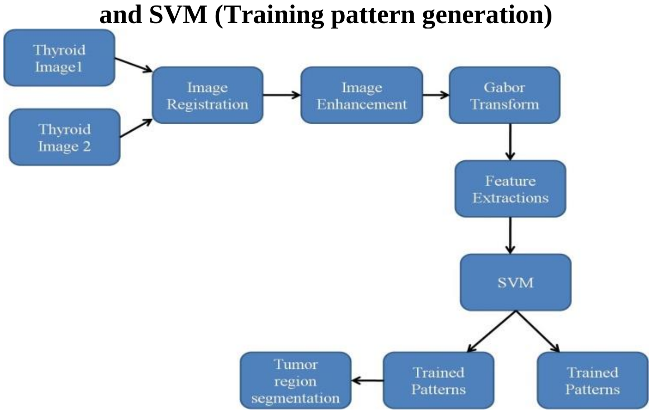

Fig. 3. Thyroid Tumor detection using image registration and SVM (Testing)

Image Registration

It is the process of aligning one image with respect to reference image. The source and reference images are required for this image registration process. Geometric transformation method is used in this paper for image registration of ultra-sonic thyroid images. The pixel coordinates from source and reference ultrasonic thyroid images are obtained and these coordinates are transformed using geometric transformation method. The final registered ultrasonic thyroid image is the aligned image with respect to reference image.

The pixel coordinates in source ultrasonic thyroid image is represented as x_i, y_i and the pixel coordinates in the reference ultrasonic thyroid image is represented as u_i, v_i. The registered final thyroid image using source and reference images as depicted using the following equation.

$$\in = argmin \left[\sum_{i=1}^{M}(xi, yi) + \sum_{j=1}^{N}(uj, vj) \right] \quad (1)$$

Where, the width and height of the final registered ultrasonic thyroid image is noted as M and N, respectively.

Image Enhancement

The registered thyroid image has low pixel contrast regions due to the alignment of the reference image with respect to source image. Hence, this contrast level of the various regions in the registered thyroid image should be enhanced before the tumor region detection and segmentation. This paper uses histogram equalization technique for enhancing the pixels contrast in the registered thyroid image. The intensity of the each pixel in enhanced image has the value greater than the intensity of the each pixel in the registered thyroid image.The histogram equalization is depicted in the following equation,

$$E = Round \left[\frac{PDF(x) - CDF(x)}{M*N}\right] * (L-1) \quad (2)$$

Where, the probability density function and cumulative distributive function of the pixel is represented by PDF (x) and CDF (x), respectively. The total number of pixels in the source thyroid image is represented as L.

Gabor Transform and Feature Extractions

The pixel coordinate variations can be changed due to its contrast enhancement process in thyroid image regions. These variations can be overcome by applying the Gabor transform on the enhanced thyroid image. The Gabor transform is used to transform the frequency-time mode functionality into multi-level pixel variants, with respect to different angle of orientations and magnitude.

From the Gabor transformed thyroid image, the following features are computed as,

$$Energy = \sum_{i,j=1}^{M-1} P(i,j) \quad (3)$$

$$Entropy = -Log \sum_{i,j=1}^{M-1} P(i,j) \quad (4)$$

These features highlight the main difference between the normal non-tumor thyroid images from the tumor affected thyroid image.

SVM classifications

The extracted features from both normal non-tumor thyroid image and tumor affected thyroid image are trained and classified using SVM classifier in this paper. This classifier classifies the source thyroid image into either normal non-tumor thyroid image or tumor affected thyroid image, based on the extracted features from the source thyroid image. Fig. 4 shows the classifications of the extracted features into two different regions using SVM classifier.

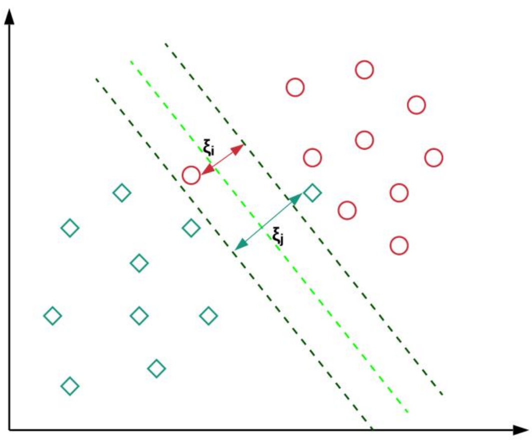

Fig. 4. SVM classifications

III. RESULTS AND DISCUSSIONS

This paper uses the following performance computation parametric equations as stated below.

$$Sensitivity\ (Se) = TP/(TP + FN) \quad (5)$$

$$Specificity(Sp) = TN/(TN + FP) \quad (6)$$

$$Accuracy(Acc) = \frac{(TP+TN)}{(TP+FN+TN+FP)} \quad (7)$$

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Whereas, these parameters are depending on the number of correctly identified and incorrectly identified tumor pixels and number of correctly rejected and incorrectly rejected non-tumor pixels in thyroid ultra sound images.

Table-1: Simulation results using MATLAB simulating tool

Thyroid images	Sensitivity (%)	Specificity (%)	Accuracy (%)
1	96.1	97.2	98.2
2	96.8	97.7	98.8
3	96.5	97.9	99.6
4	96.2	97.3	96.8
5	96.7	97.5	98.9
6	96.9	97.9	99.5
7	96.3	97.2	97.8
8	96.3	97.5	99.6
9	96.8	97.6	98.5
10	96.8	97.9	97.9
Average	96.54	97.57	98.56

Table 1 shows the simulation results using MATLAB simulating tool. This proposed method for thyroid tumor region detection obtains 96.54% of sensitivity, 97.57% of specificity and 98.56% of average tumor segmentation accuracy.

IV. CONCLUSION

In this paper, ultrasonic imaging method is used for detecting the abnormal regions in thyroid images. The thyroid gland is completely scanned by the ultrasonic scanner and the scanned image is further processed using various image processing methods in computer processing methods. This paper uses soft computing methods as the classification algorithms for detecting the abnormal regions in scanned thyroid images. This proposed method is applied and tested on different set of thyroid images and achieves 96.54% of sensitivity rate, 97.57% of specificity rate along with 98.56% of average accuracy.

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